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ABSTRACT

Most research on small group learning has focused on achievement, but few studies have systematically investigated the effects of group processes on achievement, or the influences of individual aptitudes and group composition on group processes. To investigate the relationship between student aptitudes, group process, and achievement in cooperative small groups in junior high school mathematics classrooms, and the stability of the relationship over time, students (N=105) in four classrooms participated in two studies. Initially, all students learned a one-week unit on consumer mathematics. Three months later, half of the students learned a one-week unit on probability. Students worked in four-person homogeneous-ability or heterogeneous-ability groups; they also completed achievement tests and the Eysenck Personality Inventory. Analyses of the data indicated that group process was a potent predictor of achievement in all studies; "asking a question and receiving no answer," the best predictor of achievement, was detrimental to achievement. The effects of group composition and student aptitudes on achievement were mediated by the group process variable. The mediating effect of group process and the magnitude of coefficients were stable across studies; group process was stable over time, both in average frequency and in individual student levels of participation. The results suggest a need to determine whether the stability of group process is generalizable to longitudinal designs. (Author/NRB)

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GROUP PROCESS AS THE MEDIATOR BETWEEN APTITUDES AND ACHIEVEMENT: STABILITY OVER TIME

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Group Process as the Mediator between Aptitudes and Achievement: Stability over Time

Interest in small group learning in the classroom has blossomed during the past few years. Although most of the research on small group learning has focused on achievement, few studies have systematically investigated the effects of group processes on achievement, or the influences of individual aptitudes and group composition on group processes.

Several recent studies have, however, linked group processes to achievement and have demonstrated the importance of group interaction for the learning of individual members of the group. The interaction variables found to relate to achievement in small groups include giving help, receiving help, and not receiving help. Peterson and Janicki (1979) and Peterson, Janicki, and Swing (in press) found that giving help was positively related to achievement. Webb (1980a, 1980b, 1980c) further showed that students who gave explanations learned more than students who did not give explanations, even when ability was held constant. The results relating receiving help to achievement are less straightforward. Only one study reported a significant relationship between receiving help and achievement (Webb, 1980a). Other findings suggest that the effects of receiving help on achievement depended on (1) whether the target student needed the help, and (2) whether the help included explanations rather than only the correct answer (Webb, 1980d). First, students who did not indicate that they needed help benefited less from it than students who demonstrated a need for help through questions and errors. Second, merely being told the correct answer without an accompanying explanation of how to obtain it was not sufficient for a student who asked questions or made errors to learn how to solve the problem.

A recent study examined helping behavior in greater detail (Webb, Note 1). In that study, although receiving help in response to need seemed to be mildly beneficial for achievement, not receiving answers to questions was markedly detrimental to achievement. One purpose of the present study was to replicate this finding.

Of the individual aptitudes used to predict interaction in the group, ability has been examined most often. Several studies reported that high-ability students give more explanations than low-ability students (Peterson & Janicki, 1979; Peterson, Janicki, & Swing, in press; Webb, 1980a, 1980d, Note 1). Surprisingly, few of these studies found a significant relationship between ability and receiving explanations. Those that did reported that low-ability students received more explanations than high-ability students (Webb, 1980a, 1980d). In a somewhat contrary result, Webb (Note 1) found that low-ability students were more likely than high-ability students to receive no responses to their questions. That study also reported that introverted students were less likely than extroverted students to receive responses to their questions.

One group characteristic has been shown to predict interaction in small groups: group ability composition. Comparing mixed-ability groups, with one high-ability, one low-ability and two medium-ability students, and uniform-ability groups, with students at the same ability level, Webb (1980a, 1980d) found that high-ability and low-ability students were most active in mixed-ability groups, whereas medium-ability students were most active in uniform-ability groups.

Whereas all of the above studies have examined some link in the input-process-outcome chain, only one has systematically investigated whether group process mediates the effects of aptitudes on achievement. Webb (Note 1) found that group processes mediated the effects of group composition and

personality on achievement, and partially mediated the effects of ability on achievement. The present study also investigated the importance of group process as a mediator between aptitudes and achievement.

Although recent research has investigated the relationship between group processes and achievement and aptitudes, no one has examined the stability of small group processes over time. Establishing a link between process and achievement has little practical value if group processes are unstable or unpredictable. The present study examined this question using a repeated measures design. Further, this design made it possible to determine the stability of the relationships among aptitudes, group process, and achievement over time.

The purposes of the present study were (1) to replicate the relationship between group process and achievement, (2) to replicate the mediating effect of group process between aptitudes and achievement, and (3) to investigate the stability of group processes over time, and (4) to examine the stability of input-process-outcome relationships over time. This paper presents the analyses of group process and achievement of students in junior high school mathematics classrooms who participated in two parallel studies. The results of the first study have been presented in detail elsewhere (Webb, Note 1), so only a brief summary of those results is presented here. The present paper concentrates on the second study and the relationships between the two studies.

Method

Sample and Design

The total sample consisted of 105 students in grades 7, 8, and 9. The students came from two average and two above-average general mathematics classes at a junior high school in the Los Angeles metropolitan area. Average mathematics and reading stanine scores ranged from 3 to 9 in this sample, with a mean of 6.3 (SD = 1.4). Approximately 40 percent of the students in these classes were minority. Because the mathematics classes at the school are tracked by ability rather than by age, each class had students from all three grades. One teacher taught the two average classes; the other teacher taught the two above-average classes.

All students participated in two studies. All four classes participated in the first study (Study 1) on consumer mathematics (n = 96). The two average classes also participated in another study (Study 2A) on area and perimeter (n = 51). The two above-average classes also participated in another study (Study 2B) on probability (n = 52). Because the average and above-average classes learned different topics in the second study, they were analyzed separately.

Classroom Setting

The setting for the study was a special classroom designed to complement the regular mathematics curriculum with manipulative materials. In this classroom, students worked in small groups, with instruction from the teacher when needed. Mathematics teachers had the option of taking their classes to the special classroom for week-long visits as often as they wished.

Instructional Materials

The topic of the instructional materials in Study 1 was consumer mathematics, which included, for example, calculating tips, meal tax, sales tax, and checkbook balances. The topic of Study 2A was area and perimeter,

which included finding the area and perimeter of geometric shapes and familiar objects. The topic of Study 2B was probability, which included determining probabilities of single events and combinations of events. The instructional materials for each study consisted of separate activities, each completed on a different day.

To enable the groups to check their answers to the questions in the activities and to provide clues for solving the problems, all groups had access to answer sheets.

Instrumentation

Achievement tests. At the end of each study, all students took an achievement test. The test in each study consisted of one multiple-part item corresponding to each activity in the materials for a topic. Credit was given for a part of an item if the answer was calculated correctly from earlier answers given; therefore, the accuracy of one part of an item did not depend on the accuracy of another part. The scale of each test ranged from 0 to 40 points. Internal consistency alpha was .81 for the test on consumer mathematics, .79 for the test on area and perimeter, and .86 for the test on probability.

Personality scale. Students completed the extroversion-introversion scale of the Eysenck Personality Inventory (Eysenck & Eysenck, 1968). High scores (maximum of 24) are indicative of extroversion. For the total sample, internal consistency alpha was .56.

Observation instrument. The observation instrument was designed to assess interaction among students in a group. The observation form had four columns, one for each group member, and had horizontal spaces representing one-minute intervals. Each observer wrote notes on the observation form about all interaction in the group, noting the speaker and recipient of each interchange, the observation category, and, whenever possible, the content

of the interchange. Each observer recorded one minute of group interaction in each space, thereby making it possible to estimate the amount of time per interchange.

Two persons served as observers. The training procedures consisted of instruction on the definitions of the observation categories and practice coding and note-taking. The practice trials took place over three class periods prior to data collection. During the practice sessions, the two observers recorded interaction in the same groups simultaneously. After recording each group, the observers compared notes, discussed all discripancies, and made decisions on how to code problematic interaction. By the end of the training period, the observers exhibited few inconsistencies.

To assess the reliability of the observations, a generalizability study (Cronbach, Gleser, Nanda, & Rajaratnam, 1972) was conducted in which the two observers observed the groups simultaneously on the first two days of the first study. Each observer made a tally of the number of occurrences of each observation category for each student in the class; these tallies were entered into the generalizability analyses. The observation categories and their estimated generalizability coefficients for one observer and four days were: student gives help, $\rho^2 = .86$; student receives help, $\rho^2 = .67$; student asks a question, $\rho^2 = .97$; student asks a question and receives a response, $\rho^2 = .80$; student asks a question and receives no response, $\rho^2 = .91$; student works alone, $\rho^2 = .82$; student interacts with another student (task-related, nonspecific), $\rho^2 = .87$; and student is off task, $\rho^2 = .80$. Similar generalizability studies were conducted in the other studies; most estimated generalizability coefficients for one observer exceeded .85. The coefficients were judged to be high enough that one observer observing a group at any one time was sufficient. The observations used for analysis were conducted by one of the two observers; this observer was not aware of the hypotheses of the study.

Procedure

Assignment of students to groups. Using the CTBS scores obtained at the beginning of the school year, three ability strata were defined--high, medium, and low--corresponding to the top 25%, the middle 50%, and the bottom 25% of the sample. Uniform-ability groups consisted of students from the same ability stratum. Mixed-ability students had students from more than one ability stratum. Approximately half of the groups were uniform, and half were mixed. (The percentage of groups that were uniform was 41% in Study 1, 50% in Study 2A, and 50% in Study 2B.

Because the classes were tracked by ability, the two average classes consisted primarily of medium-ability and low-ability students, and the two above-average classes consisted mostly of medium-ability and high-ability students. Consequently, most of the mixed-ability groups had either medium-ability and low-ability students or high-ability and medium-ability students. Fewer than 15% of the groups in any study had high-ability and low-ability students.

In Study 1, students were assigned to groups primarily on the basis of alphabetical order. Because uniform-ability and mixed-ability groups in that study were comparable on all measured characteristics, including ability, sex, extroversion-introversion, ethnic background, and distribution across teachers, and were comparable in friendship patterns, it was concluded that the assignment procedures did not limit the generalization of the findings. (For extensive discussion and the justification for this decision, see Webb, Note 1). In Studies 2A and 2B, students were assigned to groups at random. Students worked in different groups across studies.

Classroom procedures. On the first day of each study, students received their group assignments and their schedule of activities for the week. Activities were assigned to groups according to a Latin Square design so that groups worked on activities on different days during the week.

Students were told to work together and not to divide the work, to help group members experiencing difficulty and to ask for help if they needed it. They were instructed to check the answer sheet or ask the teacher for help only if no one in the group could solve the problem. To further promote cooperation among group members, groups participated in an intergroup competition: each group's score was the average of the test scores in the group. The group with the highest score received a prize. The reward structure was, therefore, intergroup competition-intragroup cooperation (see Michaels, 1977); groups competed for rewards but group rewards were distributed equally within each group. Deutsch (1949, 1960) found that this reward structure promoted cooperation, helpfulness, and coordination of efforts among group members.

During group work, students in a group worked on one set of materials. The teacher monitored group work by answering questions, by providing hints when groups could not proceed, and by ensuring that students worked on the task and did not bother other groups. Each group was observed for approximately seven minutes during each class period. The order in which groups were observed was counterbalanced (using a Latin Square design) so that each group was observed at different times during the class period.

Assessment. During the week after each study, students completed the achievement test for that study. Students worked individually on each test. Studies 2A and 2B were conducted approximately three months after Study 1.

Results

Summary of Results of Study 1

The results of Study 1 are briefly summarized here; a more detailed discussion of the results of this study appears in Webb (Note 1). The most potent predictor of achievement was asking a question and receiving no answer, which was negatively related to achievement ($r = -.54$, $p < .001$). No other interaction variable was significantly related to achievement. Group composition and ability also influenced achievement. Students in mixed-ability groups scored higher than students in uniform-ability groups ($F(1,93) = 5.15$, $p < .03$, analysis of covariance with ability as the covariate). High-ability students scored higher than low-ability students ($r = .52$, $p < .001$).

An explanatory model was constructed and tested in which interaction in the group mediated the effects of the input variables--group composition, student personality, and student ability--on achievement. The final input-process-outcome model (see Figure 1) partially confirmed the hypothesized model. Group composition and student personality had no direct effects on achievement, but they did have indirect effects on achievement through interaction in the group. Consistent with most educational research, ability did have a strong direct effect on achievement. Importantly, however, the direct effect of interaction on achievement was equally as strong as that of ability. The coefficients of the paths in the model show that students in uniform-ability groups were more likely than were students in mixed-ability groups to receive no answer to their questions. Within one type of goruping, low-ability students and introverted students were more likely than were high-ability and extroverted students to receive no answer to their questions.

Figure 1 about here

Results of Studies 2A and 2B

Group interaction and achievement. In the two follow-up studies (Studies 2A and 2B), as in Study 1, the interaction variable that best predicted achievement was asks a question and receives no answer ($r = -.46$, $p < .001$ in Study 2A; $r = -.42$, $p < .001$ in Study 2B). The more frequently students received no answers to their questions, the lower were their scores on the achievement test. Only one other variable was related to achievement in either study: asking a question and receiving a response ($r = -.24$, $p < .09$ in Study 2A; and $r = .34$, $p < .02$ in Study 2B). To determine whether asking a question and receiving a response helped predict achievement over and above asking a question and not receiving a response, a step-wise multiple regression analysis was performed in each study, with the interaction variables predicting achievement. In both studies, when asking a question and not receiving a response was taken into account, asking a question and receiving a response did not significantly predict achievement ($F(1,46) = 0.24$, $p < .60$ in Study 2A; $F(1,49) = 3.50$, $p < .10$ in Study 2B).

Group composition and student characteristics. The breakdown of achievement and group interaction by group composition is given in Table 1. Although students who worked in mixed-ability groups scored higher on the achievement test than students who worked in uniform-ability groups in both Studies 2A and 2B, only the difference in Study 2B was statistically significant ($t(50) = 2.91$, $p < .01$). Similarly, although students in uniform-ability groups tended to receive no answer to their questions more frequently than students in mixed-ability groups in both studies, the difference was marginally significant only in Study 2B ($t(50) = 1.79$, $p < .08$. Translating the means in Table 1 for Study 2B to frequency per class period shows that students in uniform-ability groups each asked a question and did not receive a response once in 30 minutes, on the average, or almost twice a class period,

whereas students in mixed-ability groups had this experience once in 85 minutes, on the average, or once in almost 2 class periods.

Table 1 about here

Surprisingly, neither ability nor extroversion-introversion significantly related to achievement. All correlations in both studies were less than .19 ($p < .18$).

Explanatory Models. To replicate the results of Study 1, an explanatory input-process-outcome model was constructed for each study, in which group interaction mediates the effects of group and individual characteristics on achievement. These models were estimated and tested using path analysis. Figure 1 presents the final input-process-outcome models and Table 2 presents data regarding the fit of the data to the final model. The actual and reproduced zero-order correlations are very similar, indicating a good fit (for descriptions of the analytic procedures, see Bentler, 1980; Duncan, 1975; Wolfle, 1980).

Table 2 about here

The final models in Figure 1 substantially confirmed the hypothesized models. In Study 2A, the input characteristics had only indirect effects on achievement through interaction in the group. Controlling for extroversion-introversion, students in uniform-ability groups were more likely than students in mixed-ability groups to receive no answers to their questions, with detrimental effects on their achievement. Controlling for group composition, introverted students were more likely than extroverted students to receive no answers to their questions. The final model in Study 2B was similar to that in Study 2A, except that group composition had a direct effect on achievement as well as an indirect effect through group interaction. In neither explanatory model did student ability have a direct effect or an indirect effect on achievement.

Stability of Group Interaction Over Time

In addition to examining the results of each study, a major purpose of this study, and the reason for using a repeated measures design, was to investigate the stability of group interaction over time. The means for asking a question and receiving no answer were very similar across studies (see Table 3). Correlated t-tests showed that the slight differences were not statistically significant ($t(48) = 0.32$, $p < .80$ for average classes; $t(46) = 1.06$, $p < .45$ for above-average classes). The level of asking questions and receiving no response, therefore, remained constant from the first study to the second study for both samples.

Not only was the level of this interaction category stable over time, but also the correlations between group interaction in the first study and group interaction in the second study ($r = .43$, $p < .01$ for average classes; $r = .27$, $p < .06$ for above-average classes) revealed that individual students' experiences tended to remain fairly stable over time. Students who often asked questions without receiving answers in the first study tended to do so in the second study. Students who rarely asked questions without receiving answers in the first study tended to have a similar experience in the second study.

To test the hypothesis that group composition might affect the relationship between group interaction at times 1 and 2, correlations were calculated separately for students who worked in the same type of group (mixed-ability or uniform-ability) during both studies and for students who worked in different types of groups in the two studies. It was hypothesized that the students who remained in the same group composition across studies would exhibit more stable interaction patterns than those working in different group compositions. This hypothesis was confirmed in the average classes but not in the above-average classes. In the average classes, the

relationship between asking a question and receiving no response in the first and second studies was fairly strong for students who worked in the same group compositions in the two studies (r = .48, p < .02), and was not significant for students changing group compositions from one study to the other (r = .18, p < .37). The difference between correlations, tested using Fisher's Z transformations (see Guilford & Fruchter, 1978) was significant (z = 1.73, p < .05). For above-average classes, on the other hand, the correlations among students working in the same group composition across studies and those working in different group compositions were nearly identical and not significant (r = .31, p < .13 and r = .33, p < .14).

Discussion

The results of the follow-up studies (Studies 2A and 2B) replicated the findings of the original study (Study 1). First, a strong link emerged between group process and achievement. Not only was asking a question and receiving no response the group process variable with the strongest relationship with achievement, it was a more potent predictor of achievement than any other variable. This group process variable had a negative relationship with achievement. The detrimental effect of not receiving any response to a question is hardly debatable. Since questions usually signified a lack of understanding about how to solve the problems, receiving no repsonse would leave intact the student's lack of understanding.

The second replicated finding concerned the mediating effect of group process between aptitudes and achievement. In the first follow-up study, group process mediated the effects of both input variables, group composition and extroversion-introversion, on achievement. In the second follow-up study, group process partially mediated the effects of the input variables on achievement. In both follow-up studies, extroversion-introversion had only an indirect effect on achievement through group process. Holding group composition constant, extroverted students were more likely than introverted students to receive answers to their questions. The higher incidence of receiving answers for extroverted students than for introverted students is consistent with the literature finding positive correlations between participation in groups and measures of extroversion-introversion (Bass, McGehee, Hawkins, Young, & Gebel, 1953; Grosz & Wagoner, 1971; Stern & Grosz, 1966; Webb, Note 1). The relationship between group composition and group process was consistent in both follow-up studies. Students in mixed-ability groups were more likely than students in uniform-ability groups to obtain answers to their questons. Students in mixed-ability groups may have perceived the range

of ability in the group and a need to help the least-able members. Students in uniform-ability groups, on the other hand, may not have recognized other members' need for help. Although no data are available in the follow-up studies that bear upon these speculations, students' comments in the first study provide some basis for the hypothesis (see Webb, Note 1).

The lack of relationships between ability and group process and achievement in the explanatory models in the follow-up studies is somewhat puzzling. Restriction of range in ability may in part account for the lack of relationship in the second follow- up study (Study 2B). Compared to the range of ability scores in total sample of 3 to 9, the ability scores in Study 2B ranged from 5.5 to 9. In fact, 85% of the scores were between 6 and 8. Restriction of range in ability does not account for the lack of a relationship for ability in the first follow-up study (Study 2A), however, because ability scores in that study ranged form 3 to 8.5 and were normally distributed. More data are needed to explain this finding.

Not only did the present findings replicate those of the original study, but they also showed that students' behavior in small groups tended to be stable over time, even though students did not work in the same groups in the original study and in the follow-up studies. That the behavior of students who remained in the same group composition in both studies was more stable than that of students who changed group composition suggests that styles of interaction among group members depends on the group environment as well as individual attributes. The stability of interactive styles suggests that once group combinations in the classroom are established that promote interaction beneficial for achievement (e.g., answering students' questions), such groups may need little monitoring to prevent interactive patterns detrimental to achievement (e.g., not answering students' questions)

from emerging. Groups that exhibit detrimental interaction patterns at the outset, on the other hand, may be equally likely to maintain those patterns over time. It may be necessary in such groups, therefore, to change group membership.

Although the stability of interactive patterns is suggestive, the design of the present study may limit generalization to long-term group behavior. In the months between the original study and the follow-up studies, students spent little time working in small groups. There was, therefore, little opportunity for group process to evolve. A task for future research, then, is to determine whether the stability of group process demonstrated in the present study will generalize to truly longitudinal designs.

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Footnotes

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Table 1

Distribution of Achievement, Ability, and Group Interaction by Group Composition

	Study 2A				Study 2B			
	Uniform-ability (n = 26)		Mixed-ability (n = 25)		Uniform-ability (n = 26)		Mixed-ability (n = 2	
Variable	M	SD	M	SD	M	SD	M	SD
Achievement	22.5	9.0	25.4	9.6	22.7	6.3	32.1	6.6
Ability	5.7	1.3	6.2	1.7	6.8	0.3	6.9	1.2
Asks a question, receives no answer	0.9	1.2	0.4	0.8	0.8	1.0	0.4	0.6

Table 2

Actual and Reproduced Correlations Among Variables in Explanatory Models

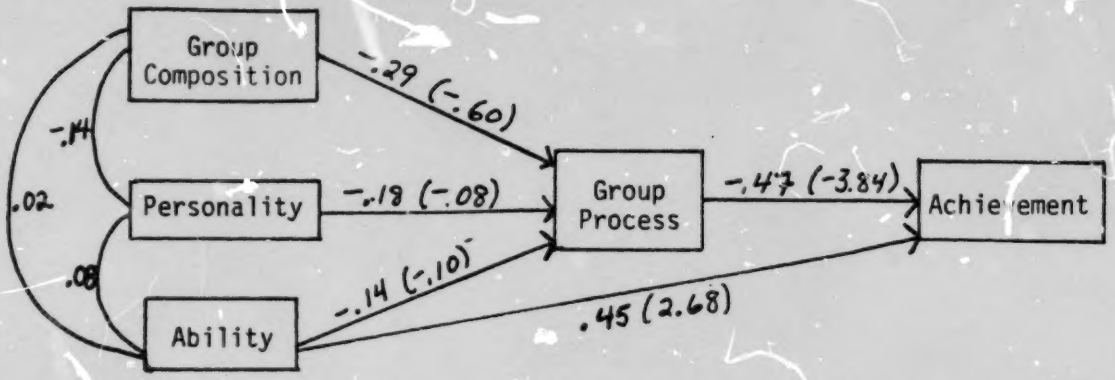
	Personality	Group Composition	Group Interaction	Achievement
STUDY 2A				
Personality	--	-.19	-.14	.07
Group Composition	-.19	--	-.21	.15
Group Interaction	-.14	-.21	--	-.46
Achievement	.06	.10	-.46	--
STUDY 2B				
Personality	--	.14	-.18	.16
Group Composition	.14	--	-.25	.38
Group Interaction	-.18	-.25	--	-.42
Achievement	.11	.38	-.42	--

Note: Actual correlations appear above the diagonal; reproduced correlations appear below the diagonal.

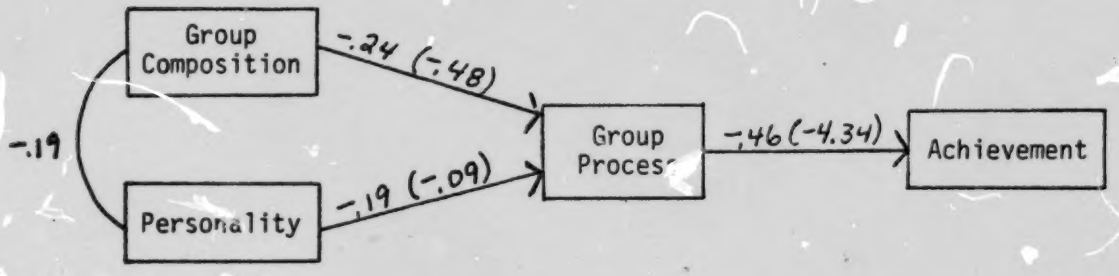
Table 3

Means and Standard Deviations of Group Interaction Across Studies

	Asks a Question and Receives No Response			
	Study 1		Study 2	
Classes	M	SD	M	SD
Average (n=49)	0.6	1.0	0.5	0.8
Above-average (n=47)	0.8	1.2	0.6	0.9



STUDY 1



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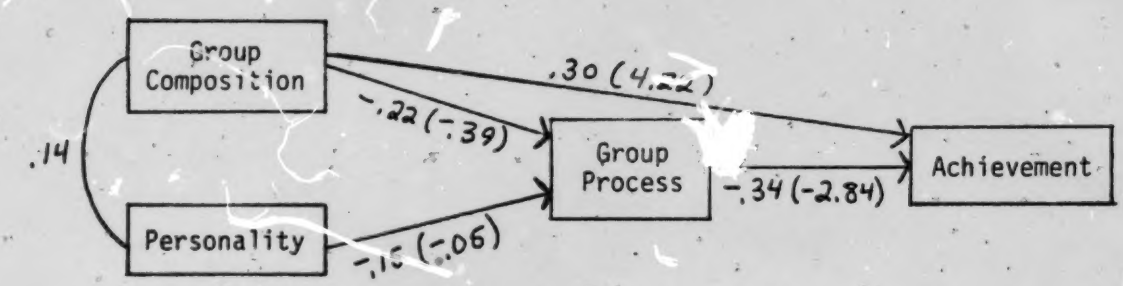

STUDY 2B

Figure 1. Path models of aptitudes, group process, and achievement. (Numbers without parentheses are standardized partial regression coefficients. Numbers in parentheses are unstandardized partial regression coefficients. Numbers on curved lines are zero-order correlation coefficients. Group composition was coded: uniform=1, mixed=2.)